Iowa State Research Farm Progress Reports

1-1-2015

Developing Hybrid Aspen as a Complementary Energy Crop

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Abstract

Our objective is to develop hybrid aspens as an energy crop that would fit as one part of systems for biomass energy production in the Corn Belt. Most liquid fuels are derived from biomass from cornstarch and cellulose. An additional perennial energy crop coming from in-field buffer strips and windbreaks could contribute to soil conservation, improvement in water quality, year-round harvesting with reduced need for storage of feedstock, and reduced energy and financial inputs. Wood biomass has about twice the energy density and therefore can be economically transported further to a conversion site. Woody biomass is the preferred feedstock for pyrolysis production of liquid fuels and can be a major component of combustion fuel for power plants.

Keywords

Natural Resource Ecology and Management

Disciplines

Agricultural Science | Agriculture | Agronomy and Crop Sciences | Forest Biology | Natural Resources and Conservation

Developing Hybrid Aspen as a Complementary Energy Crop

RFR-A1457

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Introduction

Our objective is to develop hybrid aspens as an energy crop that would fit as one part of systems for biomass energy production in the Corn Belt. Most liquid fuels are derived from biomass from cornstarch and cellulose. An additional perennial energy crop coming from in-field buffer strips and windbreaks could contribute to soil conservation, improvement in water quality, year-round harvesting with reduced need for storage of feedstock, and reduced energy and financial inputs. Wood biomass has about twice the energy density and therefore can be economically transported further to a conversion site. Woody biomass is the preferred feedstock for pyrolysis production of liquid fuels and can be a major component of combustion fuel for power plants.

Most research on wood biomass for energy has been focused on hybrid willow culture in the northeastern United States and hybrid cottonwoods in the Pacific Northwest. However, the highest yields achieved so far have been in Iowa with the naturally occurring hybrid aspen (European white poplar × native bigtooth aspen). This hybrid grows very fast and, when harvested, can re-sprout at stand densities of 80,000 stems/acre or more, reaching heights of as much as 10 ft the first year of regrowth. However, that also creates the most significant drawback to this crop. By the second year of growth, stem-to-stem competition begins to create mortality that detracts from harvest potential. Consequently, a series of plot inventories has commenced to better quantify the losses to competition, eventually to model optimal harvest schedules, and hopefully, find management techniques to reduce within-field competition and improve harvestable biomass production.

At the end of the 2014 growing season, inventory plots were harvested in one- and two-year-old re-sprouting plots on the Uthe Farm near Luther. At the Northwest Research Farm (NWRF), we harvested four-year-old re-sprouting plots.

Materials and Methods

As part of a statewide species suitability trial, a 10-acre plot of the Crandon hybrid aspen clone was planted on a 6 × 10 ft spacing near the headquarter building in April 1996. At the end of the 10th growing season, it was estimated to have produced an average of 10 dry tons of biomass per acre/year. However, the stand was not harvested until the winter of 2010/11, when all the original stems (74) were cut down. That led to the current study of re-sprouting potential. The original trees harvested in 2010/11 ranged in size from 5.3–15.0 in. diameter with an estimated average height of 46 ft. Re-sprouting from roots and stumps was vigorous. No weed control or fertilization was done. At the end of four growing seasons, all the surviving and standing dead stems were harvested with a power brush saw or chainsaw. Six nominal 6 × 10 ft plots were harvested, each centered on a stump from the original stand and the adjacent root sprouts. Another four plots were centered between the original rows of trees to look only at root sprouting. For each plot, all sprouts were classified as stump or root (alive or dead but standing), plus diameters and heights. Fresh weights were measured in the field just after cutting. Dry weights were determined on subsamples of the harvested material. Exact plot areas were measured for each plot and converted to a percentage of an acre. Those values were used to project per acre sprout numbers, live biomass, and potentially harvestable dead biomass. Standard deviation values were computed to show the level of variation in the sprout values across the plot.

Results and Discussion

Live root sprouts/acre were projected to be 7,824 ± 2,835 and live stump sprouts had an estimated 1,777 ± 1,816 stems/acre. This is a substantial decrease from 78,000 stems/acre tallied in one-year-old plots and 44,000 stems/acre for two-year-old plots at the Uthe Farm. Unfortunately, at this time we had no three-year-old plots to compare. We did find an estimated 18,150 dead standing root and stump sprouts at the NWRF, but we do not yet have good data on how long dead sprouts of different sizes remain standing and potentially harvestable. For the most part, no other woody plants were beginning to invade the understory. A few silver maple trees were seen outside the 10 plots and a total of 18 mulberry trees were found on 2 of the 10 measurement plots.

A total of 18.0 ± 5.6 dry tons/acre were estimated for the harvest of live root and stump sprouts. However, the standing dead sprouts project to only 1.3 ± 0.6 tons/acre indicating that substantial decay already has occurred in these stems. Considering that total dry weight can reach 100 tons/acre in 10-year-old stands, we have a lot to learn in how to manage sprout stands to get to an average production of 10 dry tons per acre/year with younger stands. This four-year-old stand only averaged 4.8 dry tons per acre/year. Finding ways of substantially reducing initial stem densities and competition with mechanical or chemical thinning may be the answer.

Average root sprout heights were 18.3 ± 1.2 ft and stump sprouts averaged 18.4 ± 1.0 ft. Such heights might be appropriate for designing dynamic in-field windbreaks. Basal stem calipers averaged 1.7 ± 0.3 in. for root sprouts and 1.6 ± 0.2 in. for stump sprouts. However, the largest sprouts had basal diameters in the 3-in. category. That might be at or above the upper limit for using forage-chopping equipment to harvest re-sprouting stands, which currently is being considered. Harvesting of three-year-old stands might be more practical if the biomass yields would be acceptable.

Conclusions

Further research is needed to better understand the tradeoffs between stand density, age and size of stems, yield, economic feasibility, and side benefits such as field wind speed reduction.

A new series of sprout stands at the Uthe Farm will be followed over the next three years to answer some of these questions. We also have begun modeling stand density behavior as a function of self-thinning. We have developed a cooperative research effort with two Swedish researchers who have 12 years of data on self-thinning and controlled thinning in similar hybrid aspen stands in their country. The data collected on our four-year-old trees at NWRF and the two younger stands at the Uthe Farm will allow us to evaluate how closely self/controlled-thinning models for Swedish trees fits our Iowa trees.

Acknowledgements

This project was supported by Incentive Account 490-46-02-38-5356. The authors thank Matthew Monahan, Cameron Adams, and Will Wagner-Ertz for their help in harvesting the trees and collecting the field data.